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Accumulation and Elimination of Cadmium in Liver and Kidney of Catfish *Heteropneustes fossilis* (Bloch.)

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ABSTRACT:
The present study was conducted for cadmium accumulation and elimination during and after 60d of sublethal cadmium (12ppm; 10% of 96h LC_{50}) exposure. Fish were distributed in 50 l aquaria supplied with well water. The exposure phase was followed by a 45-day depuration period. The element cadmium was assayed using atomic absorption spectrophotometry. The data showed that cadmium exposure produces significant cadmium uptake in tissues. Cadmium concentrations increased sharply in kidney than liver. After 45 days of elimination no loss of cadmium was observed in kidney.

Keywords : Cadmium, accumulation, catfish, *Heteropneustes fossilis*

INTRODUCTION

Heavy metal contamination may have gross biological impact on aquatic organisms [1] including fishes which are the inhabitants and cannot escape from the detrimental effects of these pollutants [2]. Moreover, fish being widely used to evaluate the water quality because pollutants build up in the food chain and are responsible for adverse effects and death in the aquatic systems [3] due to the alterations in physiological activities and biochemical parameters both in tissues and in blood [4]. The heavy metals such as lead, mercury and cadmium are known to cause public health hazards [5]. Among heavy metals cadmium has been chosen for the present study because it is a wide spread metal pollutant of high toxicity not only to warm blooded vertebrates but also to aquatic animals including fishes [6]. The largest source of cadmium release to the general environment is the burning of fossil fuels (such as coal or oil) or incineration of municipal waste materials [7]. Cadmium may also escape into the air, from zinc, lead or copper smelter [8]. It can enter waster from disposal of wastewater from households or industries [9]. Fertilizers often contain some cadmium [10]. Fish accumulate cadmium from polluted environment resulting in accumulation in their tissues [11]. Metal distribution between the different tissues varies depending on the source of uptake, diet and/or water-borne exposure [12]. Whatever the exposure method, cadmium accumulates significantly in gills, liver, and kidney [13]. Consequently, many studies focused on cadmium accumulation in these organs. The present laboratory study was designed to examine the accumulation of cadmium in the kidney and liver of catfish when exposed to a cadmium concentration of 10ppm for 60 days. The elimination of cadmium from catfish tissues was then tested over 45 days following transfer of the fish to cadmium-free well water.

MATERIALS AND METHODS

Irrespective of the sex, healthy specimens of *H.fossilis* of 36-38 g of body weight and 18-20 cm length belonging to a single population were collected locally and were confined to large plastic aquaria bearing well water for 30 days in the laboratory for acclimation. They were fed with minced goat liver on everyday (d) for 3 hrs (h) before the renewal of the medium. Water was renewed after every 24 h with routine cleaning of the aquaria leaving no faecal matter, dead fish (if any) or unconsumed food. Prior to the commencement of the experiment, 96 h median lethal concentration (96 h LC_{50}) of cadmium chloride (99%, pure,E-Merck, India) was estimated following trimmed spearman Karber method [14] and 24 h renewal bioassay system and was found to be 120 ppm after 5% trimming. Four groups of 25 fish each were exposed separately to cadmium chloride (12 ppm; 10% of 96 h LC_{50} value) solution prepared in tap water. The experimental medium was prepared by dissolving cadmium chloride (12 ppm) in tap water having dissolved oxygen 6 ppm, pH 7.5, water hardness 40.44 mgL^{-1} and water temperature 28 ± 2 °C [15]. Each group was exposed to 50 L of the experimental medium. Parallel groups of 25 fish each were kept in separate aquaria containing 50 L tap water without the addition of cadmium chloride as controls. Feeding was allowed in the experimental as well as control groups' everyday for a period of 3 h before the renewal of the media throughout the tenure of the experiment. After the expiry of 10, 20, 40 and 60 d of exposure, Fish from each group were dissected to separate liver and kidney according to FAO methods [16]. The separated organs were put in petri dishes to dry at 120 °C until reaching a constant weight. The separated organs were placed into digestion flasks and ultrapure concentrated nitric acid and hydrogen peroxide (1:1 v/v) (SD fine chemicals) was added. The digestion flasks were then heated to 130^0C until all the materials were dissolved. Digest was diluted with double distilled water appropriately. The element Cd was assayed using Shimadzu AA 6200 atomic absorption spectrophotometer with palladium-magnesium nitrate matrix modifier was employed and the results were given as μgg^{-1}.dw. The detailed analytical procedures for metal determinations were

given in the literature cited [17]. After 60d exposure 10 fish were treated in well water for 45 days for depuration of cadmium. The data obtained were subjected to standard statistical analysis based on random sampling of five different samples from every fish of each sampling time and their respective control groups. Duncan's multiple range test was performed and the results were expressed as mean ± SEM. Values of $p < 0.001$ were considered statistically significant.

RESULTS AND DISCUSSION

In the present study, cadmium accumulation gradually increases in liver and kidney (Table 1). Liver and kidneys are the major organs of metabolic activities including detoxification to remove the toxic substances present in the blood stream [18]. In kidney, a considerable amount of cadmium was accumulated even after 45 days of elimination. This may be due to the transport of cadmium from other tissues for the elimination. The results suggest that the cadmium detoxifying system is more effective in the liver and the kidney than other tissues. Cadmium synthesize detoxifying proteins such as metallothioneins in kidney and liver [19]. It is well known that cadmium is accumulated by means of a binding mechanism involving these proteins. The metallothioneins are a class of low molecular weight, sulfur-rich proteins [20]. Metallothioneins are ubiquitous proteins present in a large number of organisms including many fish species [19]. The synthesis of these metal-binding proteins inhibits the toxic effects of the pollutant and could explain the high cadmium accumulation level in liver and kidney [19].

During the 45 days of the elimination period, the cadmium concentration in kidney increased. It seems that the elimination of renal cadmium is more difficult after higher doses of cadmium. The cadmium concentration did not vary significantly in liver. In addition, cadmium was slowly excreted by these two organs. After a cadmium exposure of 28 days, at a level of 100 $\mu g\ l^{-1}$ Cd^{2+}, during the 14 days depuration period, Yang [21] found that kidney cadmium concentration of Japanese eels continued to increase. Kuroshima [22] found that the cadmium level in the liver of girella *(Girella punctata)* continued to increase during the clearance period in cadmium-free seawater after the end of cadmium exposure. Wicklund [23] showed that cadmium accumulation in liver and kidney of zebrafish *(Danio rerio)* continued throughout the depuration period.

During the depuration phase, cadmium concentration in the liver and kidney of water-exposed rainbow trout and lake whitefish remained fairly constant [24]. Two phenomena occur simultaneously. The first is the redistribution of cadmium among tissues before its excretion. During the detoxication period, the metal may be transferred from other tissues to the liver and kidney for excretion.

Table1. Cadmium accumulation and elimination in liver and kidney of control and experimental fish (µg/g.dw)

Organs	Control	Experimental (days)				Elimination
		10	20	40	60	45 days
Liver	0.00 ± 0.00	0.98 ± 0.020	1.52 ± 0.025	1.70 ± 0.010	1.95 ± 0.017	1.02 ± 0.011
Kidneys	0.00 ± 0.00	1.05 ± 0.010	1.17 ± 0.250	1.19 ± 0.020	1.90 ± 0.010	2.06 ± 0.009

Note : The values are statistically significant at $p < 0.001$.

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